MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
STTR 05 Proposal Submission Instructions

INTRODUCTION

The MDA STTR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA STTR program please call 1-800-WIN-BMDO. Additional information on the MDA STTR Program can be found on the MDA STTR home page at http://www.winbmdo.com/. Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/bmdo.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Feb 2005 through 14 Mar 2005), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **15 March 2005.**

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please assure that your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If you plan to employ NON-U.S. Citizens in the performance of a MDA STTR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD website at http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission site on or before the 6 a.m.15 April 2005 deadline. Proposal submissions received after the closing date will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal.

Invitations to submit a Phase II proposal will be made by the MDA STTR Program Manager (PM) or one of MDA's executing agents for STTR. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

PHASE II PROPOSAL INVITATION

An MDA Program begins the process for a Phase II Invitation by making a recommendation (all MDA Topics are sponsored by MDA Programs). The MDA Program recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?),* Phase II Benefits/Capabilities (*Why it is important),* Phase II Program Benefit (*Why it is important to an MDA Program),* Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I STTR Offeror, and the Phase I Technical Monitor.

The MDA Program Phase II Invitation recommendation is made to the MDA SBIR Working Group. The MDA SBIR Working Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Steering Group based on the same criteria and the availability of funding. The MDA SBIR Steering Group will review and make their recommendation based on the same criteria as the MDA SBIR Working Group to the MDA Selection Official. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA STTR website http://www.winbmdo.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined.

MDA FASTTRACK Dates and Requirements:

The complete Fast Track application must be received by MDA 120 days from the Phase I award start date. The Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA STTR Program Manager at the address listed below, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity STTR Program Manager.

Missile Defense Agency
MDA/SB Attn STTR Program Manager
7100 Defense Pentagon
Washington, DC 20301-7100

The information required by MDA, is the same as the information required under the DoD FastTrack described in the front part of this solicitation. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior STTRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 15 April 2005.

____2. The Phase I proposed cost does not exceed $100,000.

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MDA05-T001 TITLE: Advanced Simulator for Neutron Induced Single Event Effects (SEE) in Electronics

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop and demonstrate accelerator-based techniques for simulation of neutron-induced single event effects (NSEE) in electronics to reduce or eliminate dependency on nuclear reactor based simulators for generating required neutron environments.

DESCRIPTION: Commercial Off-The-Shelf (COTS) Integrated Circuits (ICs), such as Application-Specific Integrated Circuits (ASICs), Field Programmable Gate-Arrays (FPGAs), and System on a Chip (SoCs) are widely used in MDA elements. Such circuits are vital to MDA element functionality and performance. Many of these devices have demonstrated susceptibility to neutron-induced single event upset (NSEE) [1-3]. The objective of this topic is to develop enabling technologies to produce tailored neutron flux spectrums, first free-standing, and finally in conjunction with an ionizing dose rate radiation source. Testing performed to date for NSEE susceptibility has been conducted primarily at reactor based facilities. However, the cost has been quite high due to limited throughput and increased security costs. Security costs are expected to increase in the future. On the other hand, generation of the required neutron environment using an accelerator-based facility has the potential to increase throughput due to rapid cycle rate, and should not have the special security concerns of nuclear reactors. NSEE test will require control over the peak flux and fluence, as well as the ability to tailor the spectrum [4]. In particular, MDA has interest in both atmospheric neutron spectrums, as well as enhanced neutron spectrums to simulate endo- and exoatmospheric environments. The successful proposal must address the neutron-source technology, the area of the test beam, flux of the source (minimum and maximum) and the ability to tailor the neutron spectrum for various system needs, and the ability to provide support test of complex COTS IC's in a cost-effective manner. Finally, describe how the proposed NSEE simulator system can be incorporated into a combined-environment radiation-simulator in conjunction with an appropriate dose rate simulator.

PHASE I: Demonstrate the technical feasibility of a low energy accelerator-based neutron simulator to provide economical NSEE test in electronics. Demonstrate range of neutron flux and beam area possible and ability to achieve desired neutron spectra's using an appropriate combination of demonstration and calculations. The minimum range of interest for neutron flux is 1E6 – 1E12 n/cm2/sec to characterize NSEE susceptibility in a wide range of COTS devices. Beam area should range from 1 – 100 cm2 to facilitate exposure of both single die and medium circuit assemblies.

PHASE II: Develop and demonstrate a prototype capability for NSEE testing that validates the technical and cost advantages postulated during Phase I. The prototype capability shall demonstrate a flux of at least 1E6 n/cm2/sec over an area of at least 10 cm2. The ability to tailor spectral response shall also be demonstrated, and a path to full neutron spectra tailoring capability described. Describe how the simulator can be incorporaed into a combined-environment radiation-simulator with an appropriate dose rate simulator.

PHASE III: Provide neutron test facilities for testing of electronics systems for susceptibility to weapon and terrestrial neutrons. The test facility should be capable of a neutron flux of a minimum of 1E11 n/cm2/sec over an area of a minimum of 20 cm2, with target goals of the full 1E12 n/cm2/sec and 100 cm2. The facility should be capable of tailoring the energy spectrum to closely match that of both endo- and exo-atmospheric nuclear bursts as well as the atmospheric spectrum. Develop a plan for incorporation of a dose rate simulator into the neutron simulator facility.

PRIVATE SECTOR COMMERCIAL POTENTIAL: It has been demonstrated that atmospheric NSEE is a problem for avionics and some ground-based commercial systems. Demand for atmospheric NSEE test is expected to increase as IC geometries shrink into deep sub-micron geometries. This simulator has the potential to serve a significant commercial NSEE test community as well as DoD test needs. Increasing interest in commercial space systems is also another target opportunity. Technology and a tool that supports development of radiation hardened electronics at a reasonable cost is expected to be of significant interest to developers of electronics for space based applications.

REFERENCES:
1. “The Role of Thermal and Fission Neutrons in Reactor Neutron-Induced Upsets in commercial SRAMS”, P. Griffin, T. Luera, et. al., IEEE Trans. Nuc. Sci, Vol. NS-44, No. 6, pp. 2079-2086
2. “Soft Errors a Problem as SRAM Geometries Shrink”, Electronic Business News, January 28, 2002
3. "Soft Errors in SRAM Devices Induced by High Energy Neutrons, Thermal Neutrons and Alpha Particles," Kobayashi, Hajime, et. al., Technical Digest, IEEE International Electron Devices Meeting, Dec. 8-11, 2002, pg 337.
4. “Single Event Upsets in Avionics”, A. Tabor and E. Normand, IEEE Trans. Nuc. Sci, Vol. NS-40, No. 2, pp. 120-128

KEYWORDS: Neutron radiation effects, Single Event Effects, SEE, radiation testing, radiation hardening

MDA05-T002 TITLE: Propulsion Materials Modeling for Performance Optimization and Cost Reduction

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS

DESCRIPTION: New high payoff high temperature propulsion materials currently under development include fibrous composites (eg., HfC+C, TaC+C) and cermets (eg., W-HfN). Although the modeling of continuous fiber composites is relatively mature, these new material classes do not have mature models or modeling approaches which enable microstructure optimization. Since these materials are used at their extreme limits of strength and thermal stress resistance in propulsion (eg., rocket motor) environments, such models can be used to provide valuable guidance in the development process. This property and microstructure guidance allows the materials fabrication processes to be fine-tuned for material performance and fabrication cost minimization, and minimize costly cut-and-try fabrication and testing.

PHASE I: Identify critical elements of materials models for cermet and fibrous composite materials. The critical elements address the pertinent variables associated with thermal stress and mechanical strength property requirements in high temperature propulsion systems. Identify design methodologies which will enable the use of new advanced propulsion materials. Identify critical properties to be measured. Develop preliminary material models for new cermets and fibrous composites and apply to one or representative propulsion components.

PHASE II: Complete materials model development for cermet, fibrous composite, and other types of advanced propulsion materials. Conduct material property testing and preliminary database generation for critical properties of propulsion materials. Provide recommendations for materials fabrication and processing which optimize performance and minimize fabrication cost.

PHASE III: Complete property database generation and materials processing optimization to minimize materials cost.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technical ceramics have historically seen very slow progress to commercial sector applications. The modeling methodologies to be developed can be employed to accelerate commercial transition of advanced ceramics and materials already under development by MDA.

REFERENCES:
1. Ashby, Michael, Advanced Materials and Materials Optimization

KEYWORDS: Technical ceramics, materials modeling, microstructure optimization, multi-phase materials, cermets, fibrous composites

MDA05-T003 TITLE: Airborne Detection Sensor Improvements

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: The objective of this effort is to enhance the capability of today's airborne surveillance systems for missile defense. While the primary focus of this effort is enhancement of detector capability, advancements in the other components of an infrared surveillance system that result in improved capability are also desired.

DESCRIPTION: MDA's current detection sensor does not provide the objective range and FOV capability desired to detect, classify, and track ballistic missiles. Additionally, the current system has limited capability to discriminate between missiles and other detector signals (aircraft, SAMs, etc.). MDA desires improvement in sensor capability in the following key areas (although all areas of improvement will be considered):

1) Increased FOV
2) Increased maximum detection range
3) Increased capability to correctly discriminate between ballistic missile targets and other types of tracks
4) Increased angular resolution for a 2-D passive only angle-angle track. Desired capability is for a 3-D position track with enhanced resolution. Finally, the optimal solution includes a 3-component velocity estimate with high accuracy.
5) Minimize weight, volume, power and cooling requirements to support airborne applications.

While the current MDA airborne sensor system (specifically ABL) uses LWIR detectors and an active laser ranging system, the focus of this effort is not limited to any particular detector band or technology. MDA is interested in all technology solutions that could improve its sensor performance that can be packaged for airborne applications.

PHASE I: Analyze proposed sensor technologies and applications for performance improvement. Evaluate initial packing issues and technology capability. Laboratory demonstrations of candidate technologies would be considered a plus.

PHASE II: Develop and test a bread-board/brass-board level advanced sensor system. Include sufficient analyses to evaluate system performance across a spectrum of both operating conditions and inputs (including targets, clutter, and background effects). Evaluate and characterize packaging issues to support airborne installation and operation.

PHASE III: Develop flight-certified surveillance systems that can be installed on a variety of DoD aircraft (to include ABL and other airborne surveillance platforms).

PRIVATE SECTOR COMMERCIAL POTENTIAL: These systems could be used to support Drug Enforcement and Homeland Defense (Border Control) activities. Additionally, the enhancements in the core detector technology could support a variety of manufacturing applications where process monitoring via proposed sensing technology occurs.

REFERENCES:
1. ABL Background: http://www.boeing.com/defense-space/military/abl/flash.html
2. Proceedings of the SPIE Infrared Technology and Applications Conference (#5406), 12-16 April 04 (latest proceedings of the annual conference, earlier versions of the conference proceedings would also be applicable)

KEYWORDS: Surveillance, Detector, Missile Defense, and Airborne

MDA05-T004 TITLE: Liquid/Vapor Phase Separation Technology for Airborne- and Space-Based Thermal Management Application

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: To develop a passive, compact, lightweight, and efficient coolant liquid-vapor phase separation system capable of operating under steady-state and transient loads, variable g-force, and orientation.

DESCRIPTION: High-power density electronics often operate at sub-ambient temperatures such as 10oC and generate very high heat flux, up to 500 to 1000 W/cm2, with a heat load greater than one megawatt(MW), thus requiring an efficient cooling system. Liquid-to-vapor evaporative spray cooling is potentially the most attractive thermal management approach, but recycling the coolant requires phase separation. Doing this within the constraints of allowable space, weight, and power consumption is a technical challenge because gravity is not reliable on air and space platforms.

This program seeks passive technologies for liquid-vapor separation under these conditions. The specific requirements are: vaporization temperature at 10-50oC, quality of exhaust 50-70% vapor in mass, 1 MW maximum heat load to be cooled, and duty cycle 30 s on/1 hr off (transient nature). The coolant could be ammonia, R-134a, or FC-72. The goal for this program is a stand-alone device ready to use in any phase change thermal management system that requires phase separation.

PHASE I: Develop a feasibility study of the proposed concept for phase separation under variable load, variable body force and orientation, and microgravity. Address how liquid and vapor slugs impact separation process. Assess separator's performance in turn of liquid and gas carryover. Assess scalability to MW heat rejection.

PHASE II: Perform detailed analysis, design, fabrication, and testing of prototype liquid-vapor separation system demonstrator (must be scalable to 1MW heat load). Validate models for design using data from appropriate diagnostics. Assess performance of design in simulated or actual applications.

PHASE III: Perform integration and packaging of phase-separation system into thermal management systems, such as spray cooling, for both commercial and military applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This liquid-vapor separation system could be applied in any high-power high-heat flux thermal management systems. Commercial electronics, satellite and radar manufacturing industries will benefit.

REFERENCES:
1) Rosa, E. S., Franca, F. A., Ribeiro, G. S., "The cyclone gas-liquid separator: Operation and mechanistic modeling", Journal of Petroleum Science and Engineering 32 (2001) 87-101

2) Creutz, M.; Mewes, D., "A novel centrifugal gas-liquid separator for catching intermittent flows", International Journal of Multiphase Flow 24 (1998) 1057-1078.

3) Tilton, D., Tilton, C., Entrained Droplet Separator, US Pat. No. 5314529, May 24, 1994.

4) Mondt, J. F., "Aerospace gas/liquid separator for terrestrial applications", IECEC 96; Proceedings of the 31st Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 11-16, 1996. Vol. 1, pp. 109-113.
Key words: gas-liquid separation, liquid-vapor separation, thermal management, evaporation, spray cooling, variable body force.

KEYWORDS: gas-liquid separation, liquid-vapor separation, thermal management, evaporation, spray cooling, variable body force

MDA05-T005 TITLE: Targets for RADAR Calibration and Test of Advanced Discrimination Technologies and Concepts

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop innovative space technologies and systems that can provide very low-cost and adaptable cooperative targets.

DESCRIPTION: There is a need for well-characterized cooperative space targets that can decrease reliance on expensive BMDS integrated flight tests. The objective is to provide a daily, on-orbit, calibration test opportunity for BMDS assets under development and in deployment. The system will also provide an opportunity to conduct scientific research of advanced discrimination technologies and concepts. The space target system should consist of at least 2 objects: a cone of approximately 1-m diameter, 2-m length, and an approximately 1-m diameter sphere. The two objects shall be flown in close proximity (0 – 3-km separation). For initial Phase I designs, proposals should focus on radar-specific targets; however in Phase II the scope can be expanded to include optical and other targets of interest to STSS, NASA, and research observatories. Proposers may consider two or more independent spacecraft, or innovative approaches whereby only one spacecraft provides functions such as data down-link for both spacecraft. The primary innovation called for in this solicitation lies in 2 technical areas:

1) Using current space technologies and methods would result in targets that are prohibitively expensive. Innovative concepts are sought for reducing the cost to $2M per pair or less (excluding launch and mission operations). This cost-reduction can be accomplished through innovative component technologies or through the use of revolutionary new ways of flying multiple spacecraft in concert.
2) Novel concepts and ideas are sought for measuring, adjusting and/or controlling the range between the space targets. Proposers may consider mechanical attachments or the use of natural forces. Proposals that use on-board propulsion are not encouraged, due to the generally high cost of this sub-system, and will only be considered if use novel approaches that dramatically reduce system-level cost. Any concepts that use mechanical attachment between the bodies need to use materials invisible to Radar.

The system should communicate position, attitude, and temperature of at least one of the spacecraft. Concepts that can provide significantly more target objects that are traceable to different objects are encouraged. Novel concepts are also encouraged for capabilities such as changing the target attitude, shape, or temperature. The capability to deploy multiple targets is also of interest. Proposals can address the system or focus on specific, critical sub-system technologies that significantly increase capability or reduce cost.

PHASE I: The Phase I work should develop novel concept designs to sufficient maturity to allow accurate cost estimation of a flight system. This may include the fabrication of hardware needed to validate the design concept.

PHASE II: The Phase II work should result in a prototype system or subsystem ready for assessment in a realistic environment. Assessment can be accomplished through simulation, or test.

PRIVATE SECTOR COMMERCIAL POTENTIAL: A successful development of this technology will result in a continued use by MDA and other Radar tracking systems. The low-cost spacecraft coupled with the ability to provide low-cost formation control will have major commercial potential in the fields of space surveillance, DoD and commercial earth imaging, and space-based communications.

REFERENCES:
1. J.S. Przemieniecki, “Critical Technologies for National Defense,” AIAA Education Series, 1991.
2. Joseph Z. Ben-Asher, Isaac Yaesh, “Advances in Missile Guidance Theory,” Vol 180, Progress in Astronautics and Aeronautics, 1998.

KEYWORDS: Targets, Radar, Discrimination, Counter Measures, spacecraft

MDA05-T006 TITLE: Insensitive Munitions Technology

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop solid rocket motor case and/or propellant technology that will support an insensitive munitions while increasing performance.

DESCRIPTION: Insensitive Munitions (IM) are being developed in order to avoid catastrophic incidents involving the violent reaction of solid rocket motors when subject to impact, shock, and thermal stimuli. Improvements are sought in increasing the understanding of the response of solid rocket motors to various stimuli, and the application of that knowledge in the design of solid propellants and rocket motor cases. Since the IM criteria are often defined at the system level, modeling and design approaches that can be universally applied at multiple size scales (i.e., tactical to large space boosters) are preferred in order to minimize the amount of resources required to demonstrate qualification as an IM.

PHASE I: Develop physics-based models and designs of IM compliant solid rocket motor case and/or propellant technology.

PHASE II: Demonstration and validation of model predictions and IM technology. Demonstration and validation shall address scaling issues.

PHASE III: Incorporate technology and methods developed into solid rocket motors that are required to be IM compliant.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology will provide increased safety and potentially reduce operating costs for any system utilizing energetic materials. Solid rocket motors used in weapon systems as well as commercial space launch systems will be the primary beneficiary. The explosives industry also may benefit in the area of safe storage, handling, and transportation.

REFERENCES:
1. Victor, A.C., “Insensitive Munitions Technology”, Tactical Missile Propulsion, AIAA Progress in Astronautics and Aeronautics, vol. 170, pp. 273-362, 1996.
2. “Hazard Assessment Tests for Non-Nuclear Ordnance”, Military Standard, Mil-Std-2105B, 1994.
3. “U.S. Navy Insensitive Munitions Requirements,” Naval Sea Systems Command, NAVSEAINST 8010.5B, 5 Dec 1989.
4. NATO Insensitive Munitions Information Center (http://www.nato.int/related/nimic)

KEYWORDS: Insensitive Munitions, motor case, solid propellant, shock response, impact response, thermal response, solid rocket hazards

MDA05-T008 TITLE: 3D Visualization for Discrimination of Closely-Spaced and Spectrally-Matched Objects

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Complex backgrounds, adverse weather conditions, spectrally-matched decoys, masking of features due crowding of objects, and limits on sensor resolution are some of the major reasons why target discrimination remains a challenge today, and will be so tomorrow in spite of advances in automatic target recognition. There are limits to every algorithm, after which it is the human interpretation of results and resolution of conflict that can bridge the balance of uncertainty. The purpose of this topic is to consider a such a scenario, wherein the ability of a human-in-the-loop to discern a target in real-time could be demonstrably improved by using the new developments in 3D stereo-image visualization.

DESCRIPTION: New developments in the stereo vision technology combine two images taken with a small difference in view direction to create a three-dimensional image, which can be viewed without polarized glasses. This presents opportunities for 3D visualization in the situations where a mobile sensor either images a stationary target, or tracks a moving target. One example of such a sensor is a video camera aboard a UAV. In addition, there are opportunities when a stationary sensor tracks a moving target.

Scenarios in which one sensor, say Sensor-A, needs to execute in near real-time on the basis of actionable information gathered by another sensor, Sensor-B, are of particular interest to this topic. Sensors A and B would have a different direction of approach and view towards the target. Furthermore, the target may be crowded by features in its environment, or spectrally-matched countermeasures. The projected view of the target and its vicinity for Sensor-B would be different from that for Sensor-A; and it would change in time. Sensor-B data results in information that is based on its view of the target, which would be transformed to the view direction for Sensor-A, and presented to a human-in-the-loop for the operation of Sensor-A.

PHASE I: Select a scenario and its parameters that involve dynamic cross-cueing of two or more sensors, which are observing a moving target embedded in a crowded environment. Define a baseline capability and architecture for managing the information gathered by the two sensors, and identify limitations for the baseline capability when the scenario parameters assume a certain set of unfavorable values. Demonstrate feasibility of using the 3D representation of Sensor-A data in order to relieve one or more limitations in the baseline capability that was identified earlier.

PHASE II: Refine the Phase I scenario based upon the results of feasibility demonstration. Characterize the performance of the 3D stereo-image representation of Sensor-A data to enable a correct decision at Sensor-B. Simulate this scenario for a variety of permutations for its parameters, as well as utilize relevant historical or archived data, to develop a metric for correct identification of target, and for rejection of countermeasures. Develop a prototype simulation toolkit wherein the 3D stereo-image representation of Sensor-A data for use by Sensor-B can be performed in a generic manner, so that it is useful for variants of the primary scenario used in the Phase I and Phase II work.

PHASE III: Specialize the prototype simulation environment to sensor fusion applications in one or commercial or military situations, in partnership with industry for a new generation product for complex decision support. Ground-based military applications include tracking of targets that weave in and out of environmental elements that block view by the sensors. Space-based military applications include various phases of missile defense, and the associated countermeasures. Similarly, there are biometrics-related products in the Homeland Security arena.

PRIVATE SECTOR COMMERCIAL POTENTIAL: A simulation toolkit that supports niche applications have numerous applications in the private sector.

REFERENCES:

1. Sharp Actius RD3D Notebook Computer, at www.sharp.com
2. Hall, D.L., ”Mathermatical Techniques in Multisensor Data Fusion”, Artech House, 1992.
3. Y.Bar-Shalom (ed.), ”Multitarget-Multisensor Tracking: Applications and Advances”, vol. 2, Artech House, Norwood, MA 1992.

KEYWORDS: Sensor Fusion, 3D stereo-image visualization, dynamic cross-cueing, and target extraction

MDA05-T009 TITLE: <u>Techniques For Radiation Hardening Including Electro-Optic Subsystems.</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop innovative electronic hardening concepts and technologies for current and next generation multi-color LWIR and VLWIR detectors, ROICs, and sensor-associated avionics. Leverage developments and design concepts which utilize composite or polymer technologies to reduce or produce a net zero increase in mass of this system configuration while providing a means to increase the radiation hardening level. Replacement of Be/Be alloys with such material in strategic components throughout the EKV or MKV configuration is also a desired result.

DESCRIPTION: Systems must function reliably when exposed to background radiation from space and radiation (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, space radiation, etc.). Systems must also survive and function after prolonged periods in battlefield/storage environments (Shock, vibrations, thermal, etc). Current designs rely on Commercial-Off-the-Shelf (COTS) technology. Optimal utilization of mass in a lightweight system precludes exclusive reliance on traditional shielding methods as a means of countering the adverse effects of radiation. Current efforts to replace Be/Be alloys with alternate materials provide an opportunity to reduce or maintain a net zero impact in mass while incorporating shielding materials into component structures thereby increasing the radiation hardening without the traditional corresponding mass penalty. Particular emphasis should be placed on hardening electronic components such as Read Out ICs (ROIC) supporting low temperature Focal Plane Arrays (FPAs) and multi-color FPAs designed to function at VLWIR (> 14 micrometers) and/or LWIR (7 to 14 micrometers). The Focal Plane assembly considered may include an optical filter that has to be radiation hardened. Readout electronics may be 3-Dimensional since a multicolor FPA architecture may use a stacked multi-layer approach.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed concepts. Determine feasibility of radiation hardening various Be/Be alloy substitute materials without sacrificing material performance characteristics. Consider implications for practical handling and fabrication of materials after radiation hardening. Determine feasibility of automated radiation hardening design tools, in conjunction with radiation hard foundries, to make system electronics designs, including commercial designs, portable among foundries.

PHASE II: Demonstrate feasibility of proposed concept/technology; identify and address technological hurdles. Finalize Phase I design and develop a prototype component utilizing radiation hardened Be/Be alloy substitute material. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Due to current high levels of interest of this technology in both government and industry related to ground and space based applications, there may be many opportunities for the advancement of this technology for use in both commercial and military space activities during phase III program. Partnership with traditional DOD prime-contractors should pursue since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Primary beneficiary will be space-based systems.

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KEYWORDS: Transient radiation; mitigation; Proton; Neutron; single event effects; composites Photo-detectors; In-pixel; FPA; Simulation; miniaturize; sensors; hardened electronics; hardened MEMS

MDA05-T010 TITLE: Computer Network Defense Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS

OBJECTIVE: To conduct research into developing methodologies and technologies to: detect and mitigate insider threats; allow for computer forensics data gathering for rapid response after malicious attacks; use Variable Message Format (VMF) messages; and establish Information Assurance metrics.

DESCRIPTION: The insider threat is one of the most insidious and difficult to catch threats faced by cyber security specialists and network defenders. To facilitate early and accurate detection of the insider threat, a number of new methods and ideas should be explored. First, there must be a technique to understand the behavior of information system users and to be able to determine that a user's behavior is not normal. There must be ways to accurately model human behavior against stated security policies. Also, new techniques must be developed to correlate and fuse information gathered by the numerous network sensors that exist (intrusion detection systems, network managements systems, firewalls, etc…) Additionally, cyber forensics techniques are required that allow analysts to piece together evidence of misuse in a timely and accurate manner. Together, these techniques could help to provide not only early detection of, but also mitigation of the insider threat.

Current computer forensics methodologies and technologies collect disk and system state information after a successful attack. This information is then analyzed offline by computer forensics experts to determine attack type and source in order to develop countermeasures and collect legal evidence to support the prosecution of cyber crimes. In large geographically dispersed networks, data gathering and analysis may require days or weeks. While this approach may be sufficient for commercial entities that lack stringent continuity of operations and disaster recovery requirements, it is inadequate for systems that must maintain extremely high operational reliability. The needs for a real-time forensics data gathering capability to support large, geographically dispersed networks. This capability will aid in post-attack analysis, countermeasures development, and legal prosecution.

Current commercial intrusion detection systems (IDS) perform poorly in detecting new or previously unseen attacks. They also have difficulty detecting "low and slow" attacks designed specifically to evade IDS detection. These systems also have a high rate of false alarms, which limits the use of active defenses because of the possibility of interrupting legitimate traffic. Networks make use of Variable Message Format (VMF) communications for operations and support. VMF consists of simple binary code messages that contain only a few bits of essential data. It may be possible to take advantage of the simplicity of VMF message sets to significantly improve the accuracy and reliability of attack detection by using a combination of pattern matching and anomaly detection techniques. Instead of using pattern matching on known attacks, it may be possible to use pattern matching on the VMF message sets themselves to detect attacks with a very high degree of accuracy. Once highly accurate attack detection with low false alarms is achieved, security managers can then implement active network defense to prevent attacks from having adverse effects on the weapons system.

PHASE I: Develop a system design for an insider threat detection and mitigation system; or research data gathering tools and methodologies to support real time collection, storage, and maintenance of forensic data. Show the feasibility of such an approach, and show how the proposed tools and methodologies will protect the forensics data from malicious tampering; or research the application of pattern matching and anomaly detection to Variable Message Formats to support accurate detection with low false alarms to enable active defense against attacks. Show the feasibility of such an approach, and show how the proposed tools and methodologies will protect networks; or research tools and methodologies to support Information Assurance metrics. Show the feasibility of such an approach, and show how the proposed tools and methodologies will facilitate the development and application of IA metrics.

PHASE II: Develop and test the insider threat detection and mitigation system including techniques for modeling user behavior, anomaly detection algorithms and cyber forensics techniques; or develop a proof-of-concept prototype of the real time forensics data gathering tool; or develop a proof-of-concept prototype of the VMF intrusion detection and active network defense tool; or develop a proof-of-concept prototype of an IA metrics tool.

PHASE III: Develop a configurable insider threat detection and mitigation system for network defenders and cyber security analysts in civilian and military work environments. Develop engineering prototypes of real-time forensics tools, VMF intrusion detection and active network defense tools, and Information Assurance metrics tools.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These information system technologies could be applied in any information technology environment involving complex human machine interfaces or team interactions.

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KEY WORDS: Insider Threats, Intrusion Detection, Active Defense, Real-time Cyber Forensics, Variable Message Format messages, Information Assurance metrics.

MDA05-T011 TITLE: Resilient/Non-sticking Exoatmospheric Seal Material/Mechanism

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop a resilient, innovative seal material or combination of material(s)/ mechanism(s) with seal and release properties suitable for use with an Exoatmospheric sensor. The seals will provide protection, prevent vapor intrusion and minimize outgassing during operational storage in silos and during flights.

DESCRIPTION: A current Exoatmospheric Sensor utilizes an IR/Visible Sensor that does not require an external window to protect its telescope optics in the vacuum of space. However, it does require a cover or ‘lens cap’ to protect the system while stored and during flight before it reaches an airless environment. A seal mechanism must be incorporated in the design of the cover to completely protect the sensitive components of the sensor from the surrounding environment while the system is awaiting deployment. Typical elements to be sealed out include radiation, particulates, gasses, and fluids. The sealing mechanism itself must not degrade the sensor environment through outgassing or disintegration. It must endure prolonged periods of compression (1 to 10 years) at low temperatures (100 to 550 K) under conditions of varying humidity (10 to 100%). It must survive transport, storage, and flight with attendant shock and vibration. In recent years, some space sensor systems (Chandra-ACIS, Alexis, Mars Observer PMRR) have encountered cover release problems attributable to seal adherence, either in flight or in test. To avoid this type of catastrophic failure in an Exoatmospheric Sensor, an innovative seal material or combination of material(s)/mechanism(s) with the desired seal and release characteristics must be developed and/or identified under this effort.

PHASE I: The contractor will research technology that can demonstrate cover sealing materials or mechanisms that will not lose effectiveness over time, will not contaminate sensor components, and will not adhere/stick to other Exoatmospheric Sensor components. The contractor will design, develop and test a subscale seal interface. Testing will include accelerated environmental tests for outgassing, prevention of moisture/vapor intrusion and demonstrate separation characteristics. Based on the results of the tests, the contractor will produce a design for a full scale seal and cover system. The contractor will deliver a report containing the test results, details of a preliminary design and include a plan for development and testing during Phase II.

PHASE II: Execute plans developed in Phase I by fabricating a working prototype of the sealing materials/mechanisms designed. The contractor will perform tests to quantify the ability of various materials to prevent the intrusion of moisture in various climatic/environmental conditions, measure and quantify the outgassing of the material, characterize the effect of the outgassing products on the interior of the sensor/seeker assembly and its components, measure the reduction in reflectivity of mirror assemblies and reduction of sensitivity of detector assemblies and demonstrate cover separation. A technical report will document the test results.

PHASE III: Develop a standard operating procedure for the use of the recommended technology and provide technical support Exoatmospheric Sensor contractor to ensure its acceptance and implementation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology may be adapted for use in the commercial and space industry where a reliable, non-sticking seal material/mechanism is required.

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KEY WORDS: Moisture Barriers, Outgassing, Seals, Long Term Storage

MDA05-T012 TITLE: Innovative Technologies Supporting Affordable Increases in Power, Efficiency, and Bandwidth for X-Band Radars

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Material and circuit development leading to reductions in power density, increases in bandwidth, decreases in losses, and/or increases in power and efficiency based on advanced SiGe, GaAS, wide band-gap (WBG), or other materials/devices offering affordable performance enhancements in X-Band Radars.

DESCRIPTION: By introducing power output stages fabricated from advanced semiconductor materials or materials/devices offering equal performance and footprint compared to semiconductors, there may be the possibility of lithography/ circuit/ item placement/ design iterations capable of achieving low power density (3-5X improvement) apertures with increased bandwidth (3-4X improvement) and decreased losses that support affordable (5-10X reduction) full field-of-view X-band radars. It also may be possible to increase power (2-5X increase) and efficiency while eliminating much of the waste heat generated by inefficient Transmit/Receive (T/R) Modules. The goals of this research are to provide more compact, reliable, efficient, powerful, low cost power semiconductors or other materials/devices that will support affordable full field-of-view X-band radars while decreasing the hardware, logistics, and associated operating costs required to support the large cooling systems currently needed.

PHASE I: Develop and conduct proof-of-principle demonstrations of lithography/ circuit/ item placement/ design iterations that could reduce low power density, increase bandwidth, decrease losses, and/or increase power or efficiency at an affordable price.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment.

PHASE III: Integrate technology into GMD system and demonstrate the total capability of the improved performance. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable in high power circuit design, radar and communications.

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KEY WORDS: Lithography; circuit design; transmit/receive modules; power amplifiers, X-Band Radar, UEWR

MDA05-T013 TITLE: Radiation Hardening of Solar Cells and Arrays

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Perform research and development of technologies directed at a better understanding of radiation effects on solar cells and arrays against both the natural space radiation environment as well as enhance radiation environment (man-made), and providing techniques for mitigation of those effects in order to maintain required performance in space.

DESCRIPTION: This topic is aimed a critical operational issue relating to radiation hardening of solar cells, specifically multi-junction solar cells that will become the industry standard in the future. Cells degrade in the natural environment of space to a greater or lesser extent depending on the materials and design of the photovoltaic cells. Although some studies have been conducted, and test data collected, on the performance of solar cells in a radiation environment, the mechanisms of degradation in an enhanced radiation environment (man made, particularly for the newer generations of solar cells), has yet to be established. Substantial work has been performed on the radiation hardening of electronics, mirrors, seekers, and structures of space platforms, but less attention has been devoted to the solar arrays, which are as crucial to the continued operation of a spacecraft as are the other subsystems.

The issue of protection can be addressed at a number of levels. First line of protection, which has been used in solar arrays, is to cover the PV cells with radiation protecting coatings/cover glasses. These cover glasses though effective, are relatively heavy. Other polymeric materials like POSS and liquid crystal polymers are transparent, and are being examined as possible candidates for protection. A second line of line of defense could be the materials section, design, doping, and manufacturing of the solar cells themselves. Since the solar cell is fundamentally a semiconductor device, some of the design rules being used in industry for increasing the radiation tolerance of semiconductor devices using HBD (Hardness by Design) rules could potentially be applied to solar cell manufacture.

A third line of defense, which could encompass the first two, is the development of solar concentrator arrays where the solar illumination is focused by thin film lenses on the PV cells so that each cell each receives 10x-20x the amount of illumination per cell than a standard flat-panel array. In this case the same amount of electric power can be generated with only 5-10% of the PV cells of a typical array. In this case, the protection of each cell with very thick cover glass would not provide anywhere near the weight penalty that is encountered in the traditional flat panel array. Furthermore, in multi-junction cells, radiation damage causes shunt currents that can degrade the cell efficiency particularly for flat panel arrays. In the concentrator array, however, the cells are producing 10x -20x the current per cell, and thus the shunt current is less of a factor in the degraded cell efficiency.

Finally, computer modeling and simulations of radiation effects in PV materials could be beneficial in determining how best to cope with the degradation effects of radiation, pointing to better materials selection, PV design, and design of protective coatings and glasses.

PHASE I: Identify candidate materials, designs and process technology that can offer the better protection of space solar cells against radiation effects in space. This could include techniques at the level of the photovoltaic device itself, at the level of the protective coatings or cover glasses adjacent to the photovoltaic device, or techniques at the system level such as the use of solar concentrator architectures where the added PV protection could be done without substantive weight penalties. Demonstrate the feasibility of specific techniques through modeling, analysis and assessment to support materials selection, manufacturing or system engineering to support innovative solar array designs.

PHASE II: Down select a specific design for further development to the point of a testable prototype. This could encompass one or more of the lines of defense described above. Provide subscale prototypes for radiation testing in a simulated space radiation environment. Provide a space qualifiable subscale prototype for possible flight test.

PHASE III: Provide a solar panel with the representative protection technique(s) for use in a space flight experiment. Evaluate on an actual space flight experiment to demonstrate full life operation meeting system reliability, durability, and performance in space environments.

PRIVATE SECTOR COMMERCIAL POTENTIAL: All satellites, military and commercial, suffer from the effects of solar cell degradation due to the effects of radiation. The capacity of the solar array at the beginning of life (BOL) is engineered so that enough capacity is built into the array to compensate for the degradation so that the end of life (EOL) capacity is sufficient to maintain the minimal requirements of the spacecraft. Retarding the degradation would have substantive impact on the size and weight of the solar array for both military as well as civilian commercial space systems.

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KEYWORDS: Radiation Hardening, Solar Cells and Arrays, Space Power Systems

MDA05-T014 TITLE: Rechargeable Lithium Battery Operating Life Model

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop high fidelity, mechanism-based software model to describe the long term behavior of rechargeable lithium battery charge/discharge cycling in aerospace applications.

DESCRIPTION: Cycle life models are an important tool that describe expected performance of rechargeable batteries during the many charge and discharge cycles of their operating life. These models allow prediction of operating lifetimes, design optimization and troubleshooting battery problems. Rechargeable lithium batteries (i.e. series and parallel strings of Li Ion, Li Polymer Ion or Li Polymer) are relatively new in aerospace applications, and advanced life cycle models are needed to more accurately predict battery behavior under various conditions. Because of variation between types of batteries, “generic” models are unusable for this purpose. It is necessary to develop specific cycle life models with sufficient fidelity to make reliable predictions.

The rationale for pursuing advanced cycle life models is to better accommodate the need to predict and simulate the next generation of aerospace batteries. The lithium ion cell chemistry promises approximately a 2x performance enhancement over the current generation of conventional space-qualified batteries (NiCd, NiH2) in terms of energy density (Whr/kg) and volume density (Whr/kg). Incorporating lithium ion batteries will have significant impact on future application performance in terms of power available and the saving of weight, which greatly affect launch and overall program costs.

Some of the major concerns with using lithium ion batteries for space applications include overall reliability and cycle life for long-term missions (e.g. 10 years) in low earth orbit (LEO). To date, lithium ion batteries have had limited use and testing in space but are now being base-lined for a number of European satellite programs -- mostly in the civilian commercial sector. Lithium ion has not replaced conventional batteries in US systems to any significant degree, although a number of ground test programs are underway to explore rechargeable lithium battery use for domestic commercial and military programs.

It is difficult, if not impossible, to conduct and conclude real-time life testing of lithium ion batteries since this would delay (by 5 or 10 years) making decisions regarding technology insertion. High fidelity, mechanism-based lithium ion battery models are necessary to avoid unacceptable delay. Some modeling has taken place previously at lithium ion battery vendors and other facilities, but these models do not adequately address all the significant real-world factors that affect battery operation. Building a complex, all-encompassing model will require further refinements to these existing efforts and new development describing interaction effects to serve the purposes of this announcement.

The success of, and fidelity of, these models will allow accelerated testing of different lithium ion chemistries and provide evidence for decision makers to propose adoption of lithium ion cells for specific programs. An additional result of the advanced model is to guide power subsystem designers with operational characteristics (such as temperature of operation and depth of discharge) of batteries for particular programs.

PHASE I: For phase I, a proof of concept model demonstration per the described intentions should be attempted which is capable of approximating battery behavior during cycle life by showing how the battery cells, of various capacities in various series and parallel string configurations, react to an imposed charge/discharge cycle. A suitably successful proof-of-concept demonstration leads to the possibility of a phase II effort.

PHASE II: For phase II, a higher fidelity model will be demonstrated for sets of cell configurations and variable charge/discharge profiles over extended periods of time. Variables such as non-uniform cell temperatures, cell unbalance and other identified parameters and mechanisms must be suitably accommodated. A suitable user-interface for the software model will also be demonstrated. Successful model validations against provided data from existing hardware demonstrators leads to the possibility of a phase III effort.

PHASE III: Phase III encompasses final optimization of the software model and user interface for specific aerospace applications. As well, the model will be capable of additional “real world” conditions to provide high fidelity simulation of the lithium battery and system electronics.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Lithium rechargeable batteries are quickly becoming the battery of choice for many commercial applications. A model that adequately describes the underlying mechanisms of long-term battery operation, degradation and failure would be useful to other aerospace battery users. Such a model would likely be adaptable (given security, proprietary information and system specific behavior concerns that would have to be addressed) for common rechargeable lithium cell types as used in consumer applications.

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KEYWORDS: Lithium, Battery, Rechargeable, Model, Software, Cycle-life

MDA05-T015 TITLE: Low Cost Fabrication, Inspection and Test Methods for Hardened Satellite Optics

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop low cost alternative materials / processes for fabrication, inspection and test methods to quickly and cheaply qualify and correct the mid-to-high spatial frequency surface errors as well as the low spatial frequency errors of small through large, i.e., 0.1 - 1 m, high precision, lightweight optics (telescopes and gimbals) in support of both active and passive detection in the visible through IR wavelengths.

DESCRIPTION: Many deterministic fabrication processes are commercially available that can successfully correct low and high spatial frequency surface errors from form and micro-roughness sources, respectively. However, these processes have difficulty correcting low and medium spatial frequency errors, i.e., >200 cycles over the aperture, and high spatial frequency errors, in a fast and cost efficient manner, and they involve protracted leadtimes resulting in high costs. Proposals for this topic could include the development of methods that can address these mid spatial frequency errors involving novel materials and/or processes.

Many metrology methods exist to accurately characterize the low spatial frequency errors from form, e.g., Fizeau interferometers, profilometers, etc., of the full aperture of the optic and the high spatial frequency errors from micro-roughness by sampling the optics, but not over the full aperture, e.g., white light interferometers, AFM, etc. For a deterministic process to be able to correct mid-spatial frequency errors, the errors must be accurately characterized over the full aperture. Proposals for this topic could include methods which are integrated to optical design software to accelerate inspection and test while lowering costs to accurately obtain high-resolution full aperture measurements of precision optics that include low and medium, e.g., >1000 cycles over the aperture, spatial frequency errors.

PHASE I: Develop a fabrication or metrology concept to address mid-spatial frequency errors for high precision, large, lightweight optics. Perform a proof-of-concept demonstration on a scaled sample. Develop path to scale up the process to be used on large optics.

PHASE II: Continue development of process identified in Phase I with a goal of scaling the process to be implemented on large, lightweight optics.

PHASE III: Continue development of process identified in Phase I and II with a goal of making the process robust to be used on other commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Precision optics throughout the industry e.g., photolithography, defense, space, etc., are being assigned more stringent specifications for defined spatial frequency bands. Fabrication and test methods must be developed and implemented to address this growing demand.

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KEYWORDS: optical manufacturing, optical testing, optical metrology

MDA05-T016 TITLE: Wide Bandgap Material and Device Development

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop wide bandgap [silicon carbide (SiC) and gallium nitride (GaN)] semiconductor devices for efficient, reliable, high power electrical generation, control, conversion, and distribution systems for ground, airborne and space applications.

DESCRIPTION: Materials [e.g., silicon and gallium arsenide (GaAs)] currently used for the high power amplifier components of T/R modules cannot provide the power, efficiency, or thermal performance needed for future radar capabilities. New high power device technologies utilizing wide bandgap materials such as silicon carbide (SiC) and gallium nitride (GaN) are capable of operation at significantly higher power and hence higher temperature. Wide bandgap material devices are also more efficient than those fabricated with materials such as silicon and GaAs. Implementation of wide bandgap materials/devices in radars may allow for the use of less modules for the same power resulting in significant radar size and cost reductions (and extended module life). Implementation of these devices will allow for significantly higher radar performance and durability while demanding less power, weight, and space. The concern is WBG device performance, reliability, producibility, schedule, and cost.

PHASE I: Develop high purity, semi-insulating SiC, 4H and 6H polytype, and GaN bulk substrates. Focus is on 3 and 4 inch diameter wafer size with minimal defects; impurities; high resistivity; wafer flatness; minimum total thickness variation across the wafer; and maximum usable surface area; and maximum boule length per run.

PHASE II: Develop wafer slicing and surface preparation/polishing techniques that are quick, efficient, low cost, and minimizes subsurface damage. Development of quick, superior quality epitaxy techniques for SiC and GaN on homo- and heterogeneous substrates. Development of static induction transistors, MESFETs, PHEMPT circuits and MMIC-like devices on these wafers.

PHASE III: Conduct reliability testing of discrete and packaged devices to include short-term performance verification testing; accelerated life-testing; and non-accelerated life testing (1,000-3,000 hour long tests).

PRIVATE SECTOR COMMERCIAL POTENTIAL: These wide bandgap devices can be used in a variety of commercial applications such as: the telecommunications/wireless communications industry; cell phones/cellular base stations; and commercial airport radar systems; and optoelectronics applications such as light emitting diodes/solid state lighting (from traffic lights to automobile dashboard and exterior lights), commercial signs (such as stadium scoreboards), high definition television broadcasts, and commercial power semiconductors for hybrid electric vehicles.

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KEYWORDS: Wide Bandgap, Silicon Carbide, Gallium Nitride, Epitaxy, High Power

MDA05-T017 TITLE: Laboratory Measurements and Modeling of Highly Energetic Chemistry for Radiation Signature Analyses

TECHNOLOGY AREAS: Materials/Processes, Sensors, Battlespace, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: To develop an innovative methodology for extrapolating lower temperature chemical reaction rate laboratory data with theoretical calculations in order to create a complete and accurate description of unknown high altitude plume signature chemical mechanisms.

DESCRIPTION: The ability to design effective sensors and to perform many technical intelligence functions depends on a detailed understanding of the underlying chemical mechanisms associated with missile plume signatures (ref 1). There is a basic need for detailed and accurate knowledge of several chemical reactions critical to modeling and analyses of threat missile systems. Applications include selection of optimal sensor radiation pass-bands in detection of plume exhaust and characterization of debris. Recently, well-characterized hyper-thermal gas sources (mainly atomic oxygen) have been developed that simulate the high energy conditions corresponding to many missile scenarios (refs 2,3). With accurate detection methods of the reaction products (ref 3), these ground-based measurements can provide inexpensive and robust 'anchor points' for modern computational chemistry methods. The detailed chemical and spectral information resulting from combining measurements with modern computational chemistry can fill critical gaps necessary for modeling plume signatures and for development of advanced sensors.

PHASE I: Develop an approach for combining results of chemical modeling with experimental high energy gas-phase data to create a prototype chemical reaction and radiation mechanism for missile signatures. Identify a particular chemical reaction, and apply this approach to demonstrate feasibility. Design a series of hyper-thermal ground-based experimental measurements to be performed in Phase II to include measurement of product state distributions and an estimate of the spectral signatures.

PHASE II: Using the prototype methodology carried out in phase I, carry out a series of ground-based hyper-thermal measurements. Combine these measurements with corresponding theoretical calculations to create unknown high energy reactions including detailed descriptions of the product radiating species. Generalize the approach to more complex gas species and interactions including the possibility of more than one product channel. Tie the ground-based measurements and calculations to available observations and assess the accuracy of the methods and resulting data. Integrate the approach into signature simulations.

PHASE III: Immediate military application for this technology is the modeling and analyses associated with the Space Tracking and Surveillance System as well as other military applications that model high altitude missile signatures (including exhaust plumes and fuel dumps) and combustion phenomenology. Also update theoretical chemical models for wide distribution to the commercial sector.

PRIVATE SECTOR COMMERICIALIZATION POTENTIAL: The methodologies developed and the database of reactions generated will have applications in understanding combustion and pollution chemistry. The technology will also have application in understanding the contamination environment near commercial satellites in low-Earth orbit (LEO) and in the oxidation of polymers and carbon nanotubes.

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KEYWORDS: Hyper-thermal O atoms, high altitude plume signatures, chemical reactions, collision cross sections, chemical modeling

MDA05-T018 TITLE: Innovation of Graphic Processor Units (GPU) for High Fidelity Simulations

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop high performance physics-based computational capability for CFD and Scene Generation using Graphic Processor Unit based architectures.

DESCRIPTION: Current modeling and simulation platforms use general purpose and limited performance PC-based multiprocessors with attached accelerators including graphics processing units, pixel stream combiners, signal processing units and potentially other forms of accelerators. High performance on these platforms increasingly demands high degrees of scheduling of hardware resources to overcome the overhead of highly parallel/deeply-pipelined accelerators and the communication latency of standard networking components. However, the application domain remains inherently dynamic including viewpoint changes due to moving and active sensors as well as actions of the target. Innovative and revolutionary architecture approaches are required to dynamically manage load balance and data distribution across a large-scale multiprocessor while providing sufficiently coarse work to fully use accelerators and performance guarantees to satisfy real-time constraints.

While breakthroughs continue in conventional CPU development via increasing processor clock speed and number of transistors, it is anticipated that the net computational performance from these improvements will not keep pace with increased solution fidelity requirements for next-generation plume scene generation. Detailed 3D simulations are needed to accurately portray sensitivities but they currently cannot be used within scene generation due to consequent large wall-clock solution times. This bottleneck leads to standard systems use of much simpler algorithms, with corresponding predictions. Massive parallelization of COTS hardware provides some benefit but can incur severe networking, infrastructure, and maintenance costs. Moreover, while Moore's Law predicts a doubling of transistor capacity every 18 months, the correlation with computational improvement has begun to noticeably scale off in recent years.

Alternatively, Graphic Processing Units (GPUs) are a new and innovative approach to developing high performance low cost supercomputing solutions as they represent a revolutionary exploitation of commodity parts instead of narrow specialized developments for limited military applications. Recent research indicates they may offer tremendous potential for a new level of parallelism at a very low acquisition cost and provide a possible means for delivering the detailed simulations needed within a reasonable timeframe and within reasonable facility requirements. For years the performance and functionality of GPUs has been increasing at a faster pace (~3 to 1) than Moore's Law (CPUs). Recently, the major graphics chip manufacturers have added support for floating-point computation and have released compilers for high-level languages. These GPUs are not like the array processors of the past. First, the prices of these commodity parts are more than an order of magnitude lower; the price of the highest performance graphics cards is only about $350. Furthermore, these chips are in practically every personal computer (PC), game console and workstation sold today. This provides a huge infrastructure pull to continue to improve them.

The potential performance and functionality of today's GPUs may make them attractive as co-processors for computational fluid dynamics and flow-field simulation. The goal is to develop algorithms that that exploit the inherent parallelism and vector processing capabilities of GPUs or similar commodity vector processors and map the flow-field and radiometric computations on to the computational units of the GPUs by using fragment programs. The simulation model must be based on partial differential equations that model fluid flow, thermodynamics and heat release due to plume afterburning. An example of a high payoff goal would be to use the well-known Navier-Stokes equation for viscous flow and lay out the 3D data as slices in 2D texture memory to perform 3D simulations on the GPU. Eventually, the performance of the resulting GPU-based simulation must be evaluated based on its accuracy as well as speed-up over CPU-based implementations. Radiometric transfer solutions for simulation based on these codes suffer from inaccuracies in integrated radiance for paths through the grid cells from the CFD solution. High-speed line of sight ray-casting techniques, separating geometry from computation on GPUs may make real time computation possible.

PHASE I: Perform research into the issues of optimizing plume algorithms solving detailed species kinetics equation sets and particulates using innovative exploitation of COTS developments such as GPU hardware. Issues include evaluation of data migration onto GPU like processors (exceeding Moore's law performance growth), caching, latency, algorithm alteration, and projected performance scaling. Investigate and document potential of broad commercialization of graphic-processor based supercomputing applications using commodity GPU hardware versus specialized supercomputer proprietary architectures.

PHASE II: Apply approaches investigated under Phase I to problems like the optimization and Line-of-Sight techniques for improving the performance of challenging scene generation and computational problems such as future high-fidelity plume solvers using GPU-like processor boards. The investigator should demonstrate and validate prototype hardware/software approaches, which may include, but are not limited to, high-fidelity plume simulation demonstration using GPUs. The approaches must be performed and compared with conventional techniques. In particular, infrared and laser radar predictions are of significant interest. The selected problems should be demonstrated with emphasis on accuracy and speed.

PHASE III: In Phase III should accomplish the integration of the algorithms and the prototype hardware to demonstrate and transition a volumetric solver system for numerous flow, molecular, and radiometric transport applications for commercial users. The parallel GPU-like computational technology should be transitioned to a commodity commercial supercomputing application in the private sector to positively impact MDA's computational resource costs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This project will have broad commercial impact all areas of virtual training and simulation including flight, driving, and ship simulators. This innovation will have impact in all areas of high performance graphics including digital medicine, virtual surgery, mapping, computer aided design, digital cinema, homeland defense for hidden weapon screening and air traffic control. Computational applications such as CFD, weather modeling, molecular biology and complex bio-chemical calculation/visualization could also benefit from this effort. Another application of great potential is to enhance the state-of-the-art of Digital Cinema movie projection systems for the entertainment industry by increasing dynamic range, intensity resolution, and frame-rate.

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KEYWORDS: hardware-in-the-loop, seeker testing, real time scene projection, scene generation, HWIL, FLITES, CHAMP, Real-Time CHAMP, SSGM, BEST, physics based models, GPU, ladar scene generation, radar scene generation, floating point graphics chip, load balancing, data distribution

MDA05-T019 TITLE: Multifunctional Protective Coatings for Spacecraft Surfaces

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Perform research and development on multifunctional spacecraft encapsulation coating system tailored for use in surface material systems capable of enduring harsh space environments and mitigating charging effects during space mission.

DESCRIPTION: Spacecraft materials are facing challenging requirements to meet low cost, lightweight, flexible/deployable, longer lifetimes, extended space environmental survivability, and other operational requirements. These increased stringent requirements call for higher voltage power generation/transmission that exceed the performance capabilities of current materials, components, and processes that were developed over a decade ago. Current technology of using thin Indium Tin Oxide coatings on spacecraft surfaces suffers short mission life due to its brittleness, low mechanical robustness, and fast erosion rate in space environment. Protective encapsulation coatings on existing ITO coated spacecraft surfaces are required for long mission life and to enable spacecrafts to stay on station for a longer time. Environmental factors encountered at an altitude of greater than 65,000 ft must be considered when developing the coating system. Interactions between the spacecraft surfaces and the hazardous space plasmas and harsh space environments often result in arcing, which can damage surfaces, electronics, internal components, and sub-systems. Additionally, the arc discharge actually sputters the external materials creating a cloud of molecular debris, which can be re-deposited as contamination resulting in optical properties degradation. These effects disturb the space experiments, communications, control, and operations of spacecraft, and will limit a spacecraft¡¦s performance and operational lifetime. It is a major problem for space missions in all orbits including LEO, MEO, GEO, and interplanetary space travel. This topic seeks the development of material and process technology of multifunctional encapsulation coating system addressing ITO replacement/modification, UV transparency, UV reflectivity, atomic oxygen resistance, resilience in environments of fluctuating temperatures, thermal control (active or passive, $\alpha/\varepsilon < 0.2$) resistance to solar radiation degradation, and ability to mitigate charge build-up.

PHASE I: Identify candidate materials and process technologies that can offer multifunctional advantages while withstanding the space environments. Demonstrate the feasibility of developing an encapsulation coating for spacecraft surfaces that will provide small-scale proof of functionality for long life in the space environment. The proposer will focus on, but not be limited to, system materials anticipated to be used in advanced designs, such as a partially conducting paint/surface utilizing conducting nanomaterials or technologies at the molecule level, etc. A candidate materials system will be selected for testing. Perform technical analysis and environmental simulation testing at different radiation dosage to provide results showing the capability and demonstration of the proof-of-concept.

PHASE II: Further develop the encapsulation coatings on engineering substrates relevant to MDA systems. Build/demonstrate full-scale operational prototype of final design to mutually agreed upon specifications for long life. These tests will also include simulated space flight experimental testing. Space flight experimental opportunities will be identified to perform actual in-service space flight tests of the proposed spacecraft surfaces. Based on the results, a performance comparison would be made to current designs.

PHASE III: Apply the developed encapsulation coating materials and processes to systems. Evaluate on an actual space flight experiment to demonstrate full life operation meeting system reliability, durability, and performance in space environments.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These coatings can be applied in any space satellite / vehicle in the commercial sector. Potential applications of the coatings include: communications relay, broadcast communications, weather monitoring, and electronic countermeasures. The coatings would also open new markets and applications for thin film solar cells.

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KEYWORDS: Encapsulation coatings, multifunctional coating, thin film solar array

MDA05-T020 TITLE: Infrared Quantum Emitting Arrays

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Seek innovative approaches to develop novel infrared emissive devices to replace existing resistor array infrared sources with high-apparent temperature quantum emission devices capable of high frequency modulation and large instantaneous apparent temperature change.

DESCRIPTION: Current gases sensing systems, Hardware in the Loop Infrared (IR) projection arrays, and free space IR beacons rely on the use of silicon infrared resistive emitter arrays to realistically simulate dynamic infrared objects and backgrounds at temperatures up to 700 Kelvin. Technology based on resistive arrays has many benefits including flicker-less emission, broadband output, greater than 512 by 512 pixel spatial resolution, and high frame rates. However, the dynamic range of this technology does not provide for radiometric duplication of the full range of scenarios likely to be encountered by future weapons systems. Current arrays have material (silicon) limitations in high temperature output, limiting the apparent temperature, and suffer from droop across the array due to resistive losses at high current operating conditions. Alternative methods are needed to represent images or objects. Innovative approaches are required for simulation of point and spatially extended objects whose apparent temperature may exceed 3000K. For the purpose of defining approaches, the emitter approach should be realizable within at least a two-micron band pass anywhere within the 2-14 micron band. Ideally, the source array concept should be able to achieve at least a 512-squared spatial resolution, and achieve pixel response times of less than one millisecond. One approach may be using an array of IR light emitting diodes as a infrared scene projector for testing IR detection systems, particularly thermal imaging systems or seeker systems. IR-LEDs are heterostructure devices capable of positive and negative luminescence. Several hundred microwatts of narrow band emission can be shown to be equal to a broadband resistively heated pixel representing a 3000K target in the Mid- or Long-wave IR bands. Cold scene temperatures below ambient may be able to be simulated by the use of negative luminescence. Preferably the diodes emit and absorb radiation in the 3-5 µm and 8-14 µm wavelength regions. In practice, the fundamental switching speed of IR light emitting diodes should be in excess of 1 MHz. The frame rates that may be achieved are therefore determined not by the thermal time constant of each pixel but by the frequency of the multiplexer drive circuit.

PHASE I: Develop concepts and demonstrate viability of point source multi-wavelength quantum emitters and arrays of IR quantum emitters. Identify fabrication process issues and models that will allow design prediction of performance and definition of spectral output. Identify bandgap-tailoring issues to address pushing operation to near room temperature and for cryogenic operation.

PHASE II: Develop and fully characterize prototype pixel array single and multispectral quantum IR emitters that emit over the 2-14 micrometer spectrum. Demonstrate design and process models to optimize uniformity, operational temperature range, and spectral output. Demonstrate multispectral and point source emitter arrays to simulate target signatures of interest.

PHASE III: Further develop and integrate devices for commercial and military applications in process control, gas sensing, biomedical devices, IR line of sight communications, signal simulation, sensor stimulation and testing of IR sensors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: High performance IR emitter arrays and devices would enhance instrument performance in such applications as IR spectrometers, night vision, and IR sources which could promote significant applications outside military scope in communication, night vision, weather science, material science, metrology, industrial process monitoring, and surveillance. Real-time embedded spectroscopy for auto and aircraft emission control would be greatly enhanced by this new technology.

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KEYWORDS: Infrared Light Emitting Diode, mid-wave IR, Long-wave IR, negative luminescence, antinomide LED, quantum well infrared emitter

MDA05-T021 TITLE: <u>Alternate optical materials for cryo-vacuum mirrors</u>

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop a state of the art alternate material that can be used for high quality optical mirrors in the cryo-vacuum environment of space simulation testing.

DESCRIPTION: The materials used in cryo-vacuum optical testing of space surveillance and seeker systems must hold their surface figure even when mounted to an aluminum optical bench. The distortion caused by thermal mismatches must be kept to a minimum so that the scene projected to the sensor under test simulates a real situation. The coating must be durable and have a high reflectivity throughout the infrared. There are some limitations (cost, surface roughness, coatings, etc) in the fabrication of the typically used aluminum mirrors which could be overcome with alternate materials if their performance can be proven at cryogenic conditions. Examination of such materials and associated mounting concepts is the object of this proposal.

PHASE I: Produce an innovative prototype mirror (6" diameter) concept with a mount that can demonstrate performance equal to or better than aluminum at cryogenic conditions. Reflectivity of > 90% in mid-wave infrared (MWIR) and long-wave infrared (LWIR).

PHASE II: Produce prototype alternative material mirror (30" diameter) with mount that can demonstrate performance equal to or better than aluminum at cryogenic conditions. Reflectivity of > 90% in MWIR and LWIR.

PHASE III: These alternative mirrors will be available for use for optical systems in a multitude of space sensor platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Alternate cryo-rated mirrors should be very useful and desirable in the delivery and testing of advanced space systems.

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KEYWORDS: space simulation, cryogenic, materials, thermal expansion, mirrors, vacuum

MDA05-T022 TITLE: <u>Endo-Atmospheric Solid State Optical Seeker</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS

OBJECTIVE: Develop concepts, models and prototype hardware/software for precision, lightweight optical seeker components/subassemblies that minimize the number of moving (such as gimbals and steering mirrors). The seeker components/subassemblies should be lightweight in order to reduce the mass of traditional gimbaled seeker systems, and rugged enough to operate in a hypervelocity atmospheric flight environment without losing alignment. The optical system must have sufficient sensitivity, field-of-view (FOV) and resolution to permit target detection and tracking for accurate guidance.

Proposals are encouraged that present new ideas for "solid-state" seeker concepts, components and subassemblies for atmospheric flight vehicles that eliminate the need for mechanical gimbals, and minimize (or eliminate altogether) the number and complexity of scan mirrors in the optical system.

DESCRIPTION: Hit-to-kill (HTK) ballistic missile defense relies exclusively on the precision transfer of kinetic energy from a hypervelocity kill vehicle (KV) to a hypervelocity target reentry vehicle (RV). If implemented with sufficient precision and timing, the exchange of kinetic energy results in the complete destruction of both the KV and its target. The primary guidance sensor for HTK missile defense is frequently an optical seeker – normally a passive IR seeker, active LADAR or a combination of both – contained within an aerodynamic enclosure, and protected by a window of sufficient durability to withstand the effects of aerodynamic heating, shock and vibration. The stability and precision of the seeker is critical to the guidance and control of the KV. The extreme flight environment encountered by hypervelocity KVs operating within the atmosphere, including rapid and often violent aerodynamic maneuvers, stresses even the ability of current gimbaled seeker designs to maintain track on the target. The aerodynamic enclosure severely limits the size of the seeker optical system. The hypersonic bow shock precludes a forward-looking seeker configuration, and necessitates some form of field-of-regard (FOR) or line-of-sight (LOS) control independent of the KV maneuvers, since the KV cannot arbitrarily change its angle of attack without introducing aerodynamic lift.

Conventional approaches for seeker LOS control rely on mechanically gimbaled optics within support structures to stabilize and orient the seeker Field of View (FOV). A gimbaled system facilitates the large FOR required for target search and detection, and then finer control for target track and terminal imaging. However, mechanical gimbals add significant weight, cost and complexity to the seeker, and are subject to severe thermal and structural flight loads that reduce guidance precision. Alternative technologies are desired that enable a “solid-state” optical seeker head fully integrated with a sensor array to significantly reduce seeker weight while improving seeker performance. The innovative approach should be mechanically stable when subjected to the shock and vibration induced during hyper-velocity atmospheric flight while still delivering adequate FOV/FOR and sufficient resolution for target detection and tracking. Thermal and vibration effects should not degrade the seeker’s optical performance. The processes, models, components and subassemblies developed for the seeker should be producible, reliable and contribute to low life-cycle cost, and address the following quantitative objectives:

Seeker FOV/FOR: The seeker FOV should be at least 2-degrees square anywhere within an overall FOR of +/- 5-degrees horizontal and 0-45 degrees vertical (orientation arbitrary). Focal plane resolution within the FOV should be 100-150 micro-radians or less. The FOR may be accommodated by any means including, but not limited to precision scan mirror(s), novel focal plane configurations and adaptive optics. Proposals to advance the state-of-the-art in any of these areas will be considered.

Seeker LOS pointing accuracy: The ability of the seeker to process focal plane images, resolve targets, execute feature-extraction algorithms for target aimpoint selection, etc., is dependent on knowledge of the LOS angle relative to an inertial reference. The ability of an active (ladar) seeker to illuminate a distant target is dependent on control of the LOS angle relative to an inertial reference. In both cases, high-precision, high-bandwidth, low-latency inertial measurements are a prerequisite. Inertial information at a data rate of 20 kHz and a precision of 1-2 micro-radians is desired, as well as the ability to use this information to control laser pointing is desired. Precision fiber optic gyroscope-type instruments are capable of this order of precision, but are generally too large and heavy for small, hypersonic KV applications. Proposals to advance the state-of-the-art in miniature, high-precision, high-bandwidth inertial instruments, control systems and algorithms will be considered.

Seeker Subsystems: Combining the FOV/FOR and LOS control and instrumentation invites any number of synergistic approaches involving innovative optical system design, focal plane configurations, control systems, etc. Proposals offering a holistic approach to an integrated seeker system/subsystem that accomplishes the quantitative objectives while reducing mass, volume, complexity and cost will be considered.

PHASE I: Identify the potential technology and/or process that addresses the desired functionality. Conduct analytical and/or modeling efforts to demonstrate feasibility and establish basic performance criteria and areas for further refinement in Phase II.

PHASE II: Demonstrate proof-of-principle and engineering feasibility of proposed technology, including performance predictions, mass properties estimates, and production cost estimates. Fabricate a prototype that demonstrates the critical technology and/or process defined during Phase I.

PHASE III: Develop the critical technology component/subsystem into a full-scale engineering prototype for qualification and insertion into a potential missile system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The production of this optical element technique could translate to other imaging markets involving high-precision, high-speed optical scanning applications requiring large FOV, high resolution performance. Potential markets include Homeland Security, private security, and satellite surveillance/imaging, as well as emerging MDA interceptor programs including KEI and MKV CV, and LRAD.

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